

[54] **COMPRESSOR-EXPANDER HAVING
THERMAL ISOLATION AND ADJUSTMENT
FEATURES**

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[52] U.S. Cl. **62/402; 62/86; 418/13**

[51] Int. Cl. **F25d 9/00**

[58] Field of Search **62/402, 86; 418/13**

[56] **References Cited**

UNITED STATES PATENTS

3,686,893	8/1972	Edwards	62/402
3,752,605	8/1973	Newton	418/13

Primary Examiner—William J. Wye

Attorney, Agent, or Firm—Wolfe, Hubbard, Leydig,
Voit & Osann, Ltd.

[57] **ABSTRACT**

A compressor-expander for use in air conditioning which includes a housing having a chamber of oval profile divided into a compression side and an expansion side and containing a cylindrical rotor having a plurality of outwardly biased vanes forming compartments which progressively decrease and then increase in volume as the rotor rotates. The housing has com-

pression side inlet and outlet ports and expansion side inlet and outlet ports, with the heat exchanger being connected between the compression side outlet port and the expansion side inlet port so that an incoming charge of air is first compressed, flows at constant pressure through the heat exchanger where the heat of compression is removed and then expands in the expansion side to produce a sharp drop in temperature for discharge in the cold state. To improve thermal efficiency, a flexible liner of thin cross section covers the wall of the chamber, a layer of insulation being interposed under the lining to inhibit flow of heat from the compression side to the expansion side. Means are provided for peripherally shifting the liner, if desired, to change the phase of the port positions. In one embodiment, the liner is in the form of a continuous strip supported upon insulated pedestals formed in the wall of the chamber and with diametrically opposed means being provided for applying peripheral shifting movement in opposite directions. In another embodiment, the liner has ends terminating in interdigitated fingers having a limited amount of endwise clearance so that when traction is applied to one of the ends of the liner for adjustment purposes, the effect is to reduce the diametrical dimension of the liner and thus unseat it from the wall of the chamber. When bottoming occurs at the fingers, the liner is bodily shifted to the new position. In a final aspect of the invention, the liner is in the form of a plurality of strips each of which carries a portion of the port openings and with the strips being individually shiftable to vary the relative positions of the ports.

23 Claims, 13 Drawing Figures

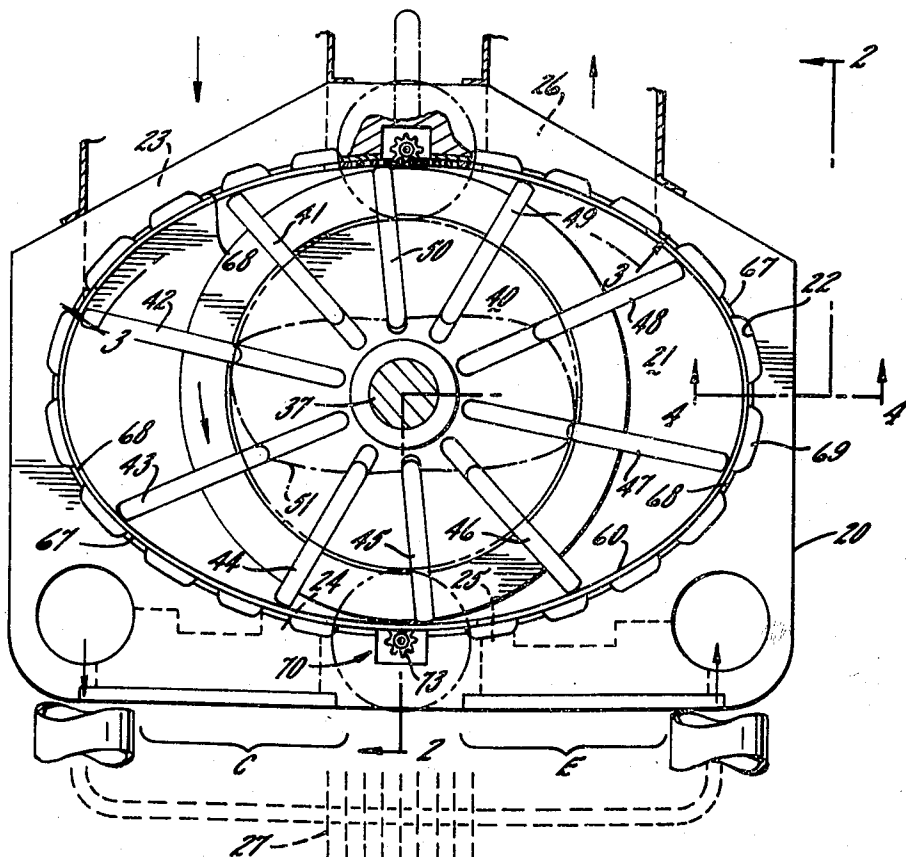


FIG. 1

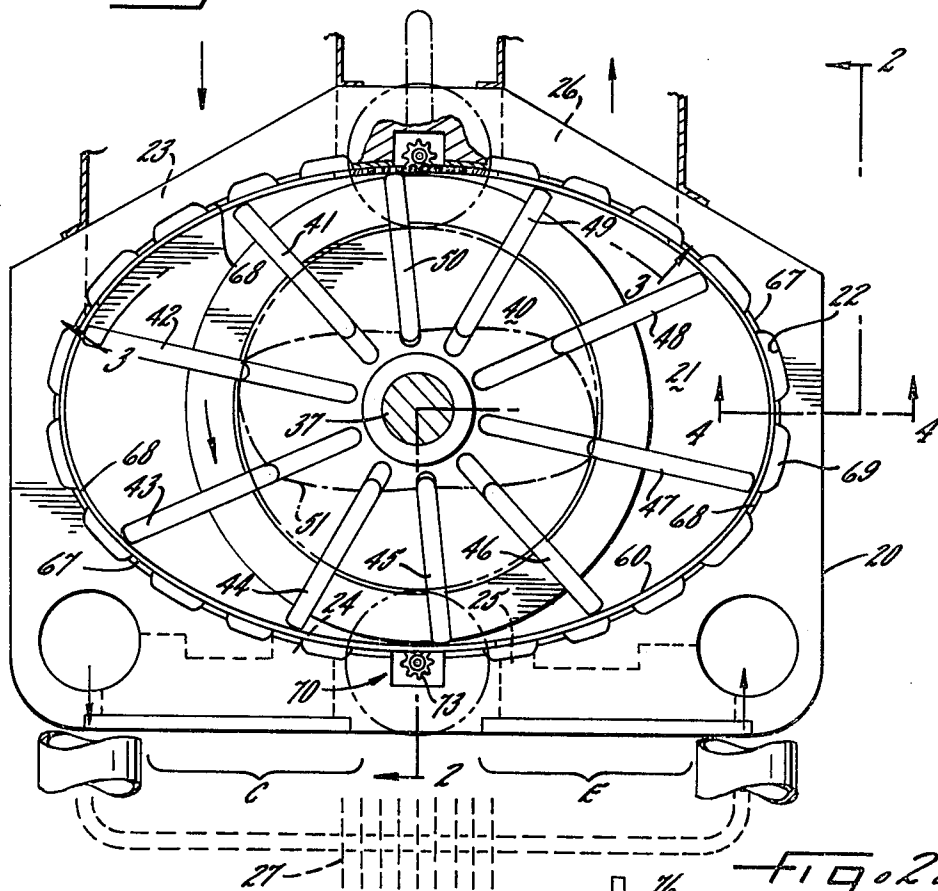


FIG. 2

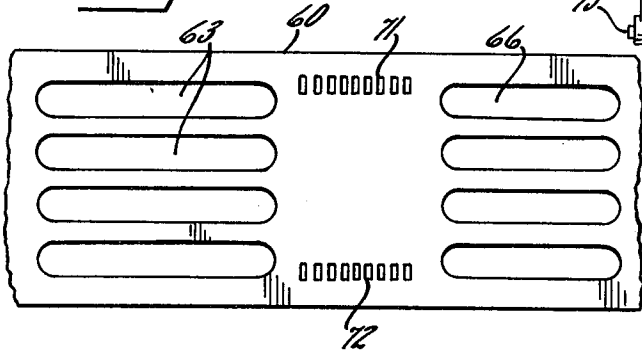


FIG. 3

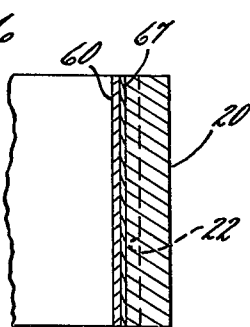


FIG. 4

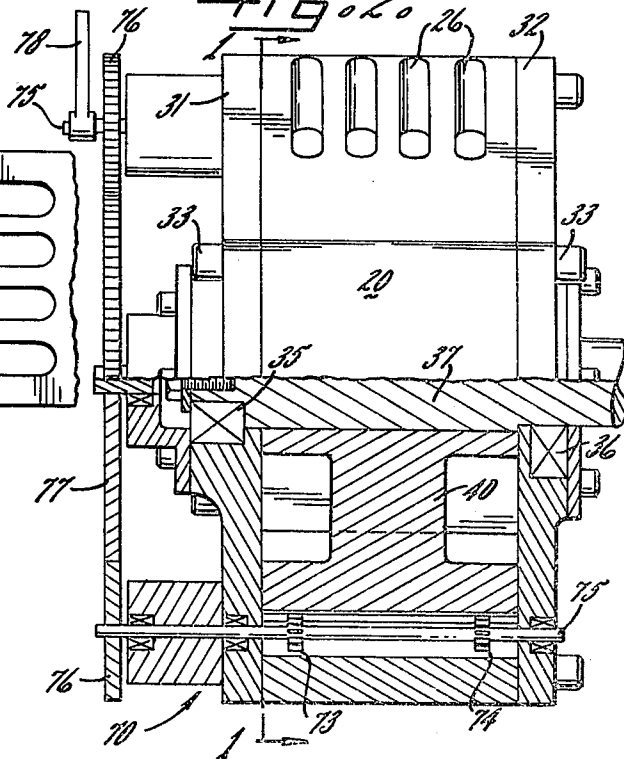


FIG. 9.

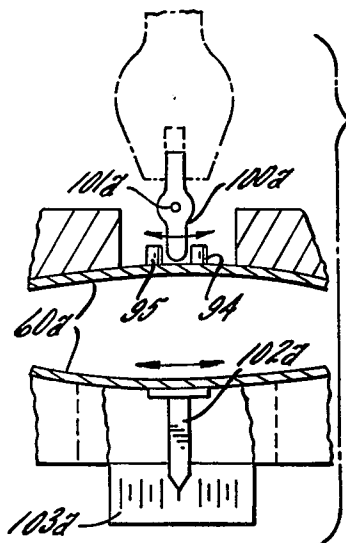
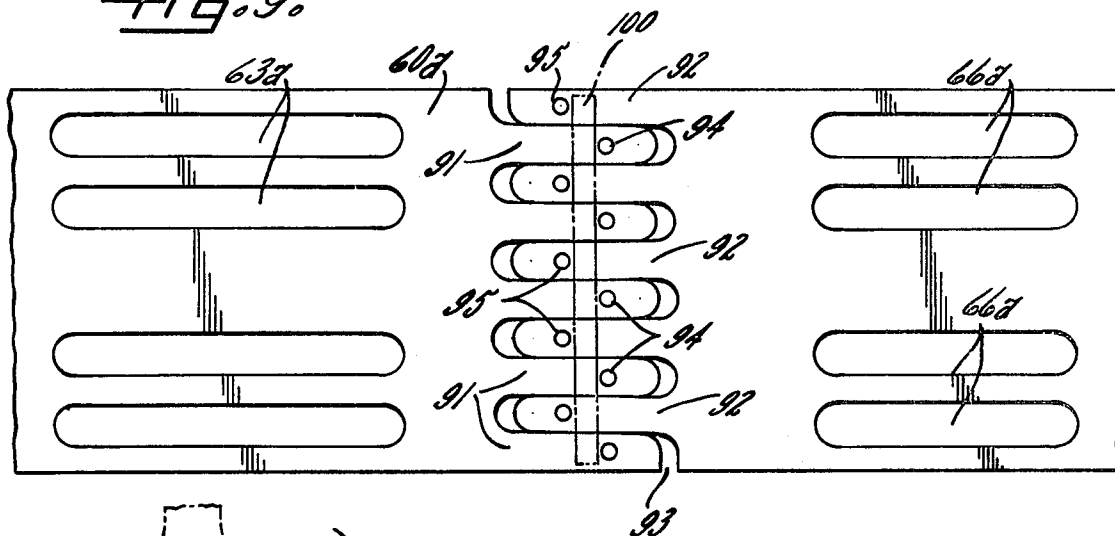


FIG. 12.

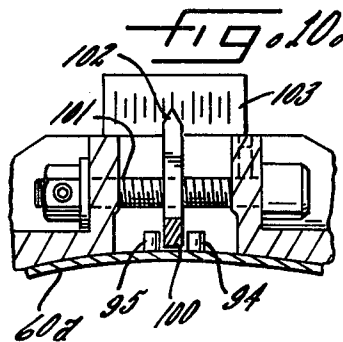


FIG. 13.

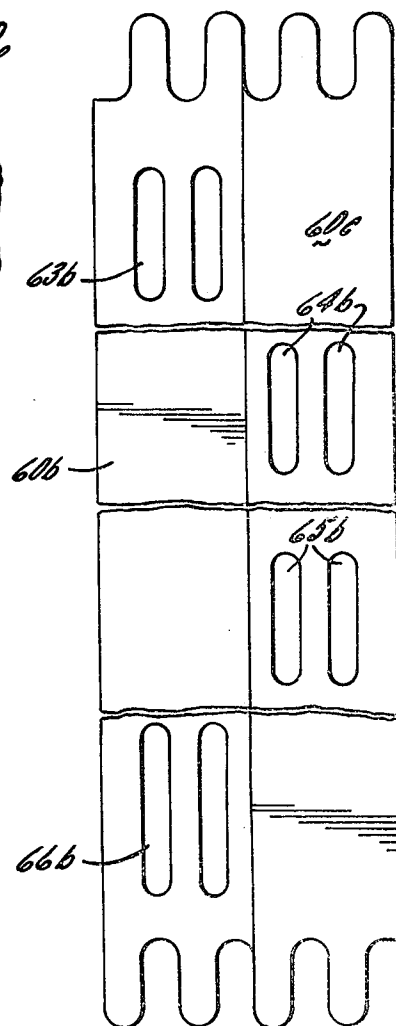
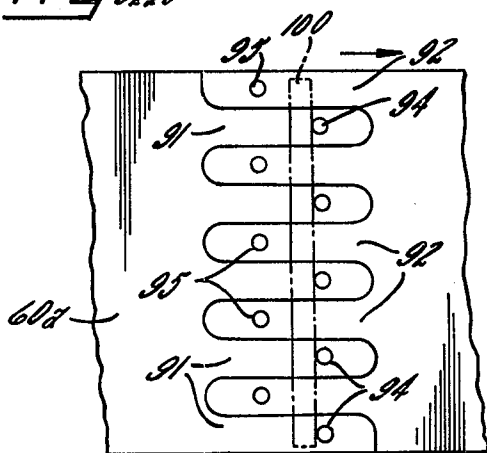


FIG. 11.



COMPRESSOR-EXPANDER HAVING THERMAL ISOLATION AND ADJUSTMENT FEATURES

In my prior U.S. Pat. No. 3,686,893, which issued on Aug. 29, 1972, there is disclosed a compressor-expander having a housing defining a chamber of oval profile having a compression side and expansion side in which a vaned rotor rotates. Inlet and outlet ports are provided in the housing, with a heat exchanger being connected between the compression side outlet port and expansion side inlet port so that a charge of air trapped between adjacent vanes is (a) compressed, (b) passed through the heat exchanger where the heat of compression is lost and then (c) readmitted to the expansion side where the air expands between adjacent vanes for discharge in the cold state. Because of the unitary nature of the device, there is a possible loss in thermal efficiency by leakage of heat from the hot compression side to the cold expansion side. Moreover, since the inlet and outlet ports are stationarily located, there is a certain rigidity in the operating conditions; for example, the device cannot be operated with maximum efficiency when there is a sudden change in the temperature of the ambient inlet air. Also, because the device works on the basis of positive displacement, the device as originally disclosed did not include provision for adjustment to insure that the outlet air is discharged at substantially ambient pressure.

It is accordingly an object of the present invention to provide a compressor-expander in which a liner of thin flexible material covers the wall of the chamber, the liner being of limited cross section and backed up with thermal insulation which may, for example, be air or plastic, to reduce heat flow from the compression side to the expansion side.

It is a further object of the present invention to provide a compressor-expander having a liner having ports formed therein which are in communication with the ports in the housing, but with the liner having provision for slight peripheral adjustment in one direction or the other so as to change the phase position of the ports with respect to the eccentric axes of the chamber thereby to control the operating characteristics. In this connection; it is an object to provide a liner having an isolation layer which is made of a material, preferably teflon, having self-lubricating properties as well as thermal insulation properties to facilitate shifting movement while providing the desired thermal isolation.

In one of the aspects of the invention, means are provided for unseating the liner from the wall prior to imparting the shifting movement thereby to insure easy shiftability even after long periods of usage.

It is yet another object of the present invention to provide a compressor-expander having a liner formed of a plurality of strips arranged edge-to-edge, each strip having openings communicating with a portion of the housing ports and with provision for independent strip adjustment thereby to achieve changes in the relative phasing between the ports so as to accommodate the unit to a wide range of operating conditions.

It is a general object of the present invention to provide a compressor-expander having improved thermal isolation between the compression and expansion sides and having novel provision for port adjustment both accomplished by the same liner structure, but which is nevertheless of simple construction and which can be manufactured at a cost which only slightly exceeds the

cost of a compressor-expander unit not including these features.

Other objects and advantages of the invention will become apparent upon reading the attached description and upon reference to the drawings, in which:

FIG. 1 is an elevational view looking along the section line 1—1 in FIG. 2;

FIG. 2 is a broken section taken along the line 2—2 in FIG. 1 showing one form of shifting mechanism;

FIG. 3 is a developed view of a portion of the liner looking along the line 3—3 in FIG. 1;

FIG. 4 is a fragmentary radial section taken along line 4—4 in FIG. 1;

FIG. 5 shows an alternate form of shifting mechanism;

FIG. 6 is an elevational view showing a modified construction of housing as viewed along line 6—6 in FIG. 7;

FIG. 7 is an end view corresponding to FIG. 6;

FIG. 8 is a fragmentary radial section looking along the line 8—8 in FIG. 6;

FIG. 9 is a developed view of modified form of liner looking along line 9—9 in FIG. 6;

FIG. 10 is an enlarged fragmentary elevation, in partial section, showing one form of adjusting mechanism;

FIG. 11 is a view similar to FIG. 9 but showing the interdigitated ends of the liner in bottomed condition;

FIG. 12 is a diagram showing a modified form of adjusting mechanism for use with the liner of FIG. 9; and,

FIG. 13 is a developed view of a liner consisting of a pair of strips arranged edge-to-edge and shown somewhat foreshortened.

While the invention has been described in connection with certain preferred embodiments, it will be understood that I do not intend to be limited to the particular embodiments shown but intend, on the contrary, to cover the various alternative and equivalent constructions included within the spirit and scope of the appended claims.

Turning now to the drawings, there is shown in FIGS. 1 and 2 a compressor-expander 20 having a central chamber 21 which is oval in profile, the chamber having an outer wall 22. For the sake of convenience, the lefthand portion of the housing 20 may be referred to as the compression side C, while the righthand portion may be referred to as the expansion side E. The housing has a compression side inlet port 23, a compression side outlet port 24, an expansion side inlet port 25 and an expansion side outlet port 26. A heat exchanger diagrammatically indicated at 27 is connected between the compression side outlet port 24 and the expansion side inlet port 25. Enclosing the chamber 21 are end plates 31 and 32 which are held securely to the member 20 by means of cap screws 33. The end members include bearings 35 and 36.

Journalled in the bearings 35 and 36 is a driven shaft 37 which supports a rotor 40 having a plurality of radially extending vanes 41-50. The vanes extend axially from one end plate to the other, and a spring band 51 is provided for urging the vanes outwardly toward the wall of the chamber.

As described in my prior patent, the adjacent vanes define compartments which change in volume as the rotor rotates. Thus, a charge of air entering the inlet port 23 and trapped between adjacent vanes 41 and 42 is progressively compressed, with the temperature of the air rising by reason of the heat of compression. The

compressed air is discharged from the compression side outlet port 24 into the heat exchanger 27 through which the air flows without any substantial change in pressure. The same air cooled to nearly ambient temperature, but still under pressure, is fed to the compression side inlet port 25 where the charge of air is trapped between adjacent vanes and permitted to expand as the rotation cycle is completed. The expansion produces a sudden drop of temperature so that the air in the cold state is discharged from the outlet port 26.

In order to inhibit the heat from the compression side from flowing through the housing to warm up the expansion side, with consequent reduction in thermal efficiency, an insulated liner 60 of flexible material and of thin cross section is interposed inside the wall of the chamber as shown in FIG. 1. It will be understood that the liner is provided with port openings which register with the ports in the housing. FIG. 3 shows two of the port openings indicated at 63 and 66 and which correspond to housing ports 23 and 26. The port openings which correspond to ports 24 and 25 are similar but are not shown. The liner may be made of any durable material, for example, as a ribbon of hard steel, or a material may be used having self-lubricating characteristics.

In accordance with one of the aspects of the invention, an isolating layer of predetermined thickness is interposed between the liner and the wall of the housing, the layer being indicated at 67 in FIGS. 1 and 4. Moreover, the inner wall 22 is grooved axially to define upstanding pedestals 68. The isolating layer is formed of material having good insulation properties augmented by the air in the dead air spaces 69. The narrower the pedestals, the less heat will flow and the pedestals may be further reduced in area by machining peripheral grooves into the internal wall 22. If desired, the dead air spaces may comprise the sole insulating means.

The thin liner with its insulation inhibits heat flow both in the radial direction and circumferentially. It will be apparent to one skilled in the art that to further limit the direct heat flow which occurs between the two portions of each of the end plates 31 and 32, the end plates may, if desired, be equipped with a similar thin thermal liner without departing from the present invention.

It is one of the features of the invention that means are provided for shifting the liner to change the phase position of the ports with respect to the eccentric axes, that is the major and minor axes of the ellipse. To do this, engaging means are preferably provided on the outside surface of the liner at diametrically spaced positions, with the engaging means being engaged and operated by a manual shifting means which penetrates the housing. Thus, in the first embodiment of the invention, in FIGS. 1-3, the adjustment 70 at the top of the device includes engaging means in the form of rows of perforations or indentations defining "teeth" and 71 and 72 which are located along the lateral edges of the liner 60. The teeth are engaged by pinions 73 and 74, respectively mounted upon a shaft 75 journaled in the housing end members. The shafts at the top and bottom of the machine terminate in gear wheels 76 which are meshed with a central gear wheel 77. Shifting movement is applied to the gear system by a manually operated arm 78. When the arm 78 is swung in one direction, the gear wheels 76 rotate equally and in the same direction. Thus, the liner is shifted in opposite direc-

tions at the diametrical points. Because of the spaced application of shifting pressure at diametrical points and because of the location of the engaging teeth 71 and 72 along the lateral edges of the liner, binding or cocking are avoided and only balanced forces are applied.

In carrying out the invention, a material is chosen for the isolating layer 67 which not only has insulating properties but which has self-lubricating properties as well, so that only light adjusting forces are required. The material which I prefer to use to achieve the combined insulating and lubricating functions is teflon, but it will be apparent to one skilled in the art that other materials, notably other plastics, may be substituted, having approximately the same insulation and lubrication features, materials either presently available on the market or which may be subsequently introduced.

In lieu of the gears 76 and 77, the upper and lower shafts 75 may be coupled together by pulleys 81 and 82 about which is trained a belt 83 (FIG. 5). To preserve the phase position, the belt may be of the toothed type referred to in the art as a timing or "cog" belt.

In accordance with a further feature of the invention, the liner, instead of being endless as disclosed in FIG. 1, is formed of a thin double-ended strip, with the ends thereof being shaped into fingers which are interdigitated together and with a small amount of peripheral clearance at the tips of the fingers. The interdigitation and peripheral clearance, combined with slight outward springing of the strip, enables the strip to be easily inserted into position, following which the strip expands into its seated position against the wall of the chamber. Unseating of the strip for maintenance or positional adjustment is easily accomplished by reversing the procedure, that is by contracting the strip.

Further, means are provided for applying traction selectively to the ends of the liner so that the liner is effectively shortened as the clearance is taken up, reducing the diametrical dimension of the liner and causing it to be unseated from the wall of the housing, following which continued traction results in bodily shifting of the liner to a new phase position. Thus, referring to FIG. 6 where corresponding elements are indicated, where possible, by the same reference numeral plus *a*, there is shown a housing 20*a* defining a central space 21*a* bounded by a wall 22*a* of oval profile. The ports are indicated at 23*a*-26*a* and the heat exchanger at 27*a*. The liner 60*a* of FIG. 9 has a full complement of port openings, but only the port openings 63*a* and 66*a* which communicate with ports 23*a* and 26*a* in the housing are shown. Just as in the first embodiment, an isolating layer 67*a* of teflon or the like is interposed between the liner and the housing and the housing is, moreover, internally machined to define axially extending pedestals 68*a* which are bounded by dead air spaces 69*a* to provide an effective barrier against the radial flow of heat either into the housing on the compression side or from the housing on the expansion side. One end of the liner is formed with fingers 91 while the other end is formed with fingers 92 which are closely interfitted in the axial direction but which provide peripheral clearance as indicated at 93. For the purpose of providing traction to the fingers 91, abutments 94 are provided, while the other set of fingers 92 have similar abutments 95. For applying traction alternately to the two sets of abutments, a unitary adjusting member 100 is used, engaged by a captive screw 101 (FIG. 10)

and having a pointer **102** cooperating with a scale **103**.

When it is desired to move the liner clockwise, the unitary adjusting member **100** is moved to the right as shown in FIG. **11** into engagement with abutments **95** on the fingers **71a**. The initial portion of the movement takes up the clearance indicated at **93** so that the size of the loop of liner is slightly reduced, breaking the liner temporarily away from its supporting surfaces. Continued movement of the adjusting member **100** after bottoming takes place causes the liner to be bodily shifted in the clockwise direction. After the liner has achieved its new position, the adjusting member **100** may be backed off to permit the liner to achieve its original seated condition. Movement of the adjusting member to the left results, similarly, to shifting of the liner in the counterclockwise direction.

An alternative form of shifting mechanism is diagrammatically illustrated in FIG. **12**. In this figure, the adjusting member indicated at **100a** may be in the form of a butterfly plate centrally pivoted at **101a** and engageable by a wrench or similar tool to first reduce the dimension of the liner and then, by continued movement, produce bodily shifting. The version of adjusting device shown in FIG. **12** has the advantage that the phase position of the liner is at all times accurately indicated by a pointer **102a** which is located at the lowermost position of the liner and which cooperates with a scale indicated at **103a**. If desired, a similar member **100a** cooperating with similar abutments may be provided in the lower position for simultaneous actuation.

In the embodiments described above, all of the port openings in the liner are changed in phase with respect to the eccentric axes to the same degree. However, in accordance with the invention, the liner may be formed not of a single strip of flexible material but of a plurality of strips of the same thickness and arranged closely side by side to span the distance between the end plates, and with a portion of the port openings being provided in one of the liner strips and a portion of the port openings in the other. For example, the liner may be formed, as shown in developed form in FIG. **13**, as two separate strips arranged side by side and which are indicated at **60b** and **60c**. The first strip **60b** carries the port openings **63b** and **66b** (corresponding to the housing ports **23** and **26**), while the second strip carries the port openings **64b** and **65b** (corresponding to ports **24** and **25**). It will be understood that each of the strips is provided with separate adjusting means of the type shown in FIGS. **10** or **12**. Alternatively, only one of the strips may be movable and the other may be relatively fixed to the housing.

The provision of a portion of the port openings in one strip and a portion in another enables a high degree of design versatility since the port openings may be provided in the strips in any desirable or conceivable combination. Moreover, since it is a simple matter to remove the strips by loosening one of the end plates, strips of specifically different porting may be readily substituted to adapt the same basic structure to widely different operating conditions.

As will be appreciated by one skilled in the art, the shifting of the ports permitted by the present invention enables the user of the machine, for example, to compensate for different temperatures of ambient air. By shifting of the outlet port opening **66b**, the discharged air may be caused to have the same pressure, at point of discharge, as the ambient air, thereby minimizing

noise level. The shifting of ports may be also employed inter alia to control the thermal load (temperature or discharge) and to compensate for changes in driving speed.

While the invention has been described in connection with a compressor-expander having vanes which are radially slideable in the rotor, such structure has been to simplify understanding of the invention, and it will be understood that the invention is by no means limited to use of sliding vanes but is fully applicable to use with tilting vanes as covered in my application Ser. No. 492,608, filed July 29, 1974.

In the above embodiments, the invention has been applied to an endless liner and one which is jointed in the top position. It will be understood that my invention is not limited to this and that I contemplate that a liner may be provided consisting of two **180°** sections jointed by interdigitation both top and bottom. In such event, an adjusting means such as that set forth in FIGS. **10** and **12** would be used in both the top and bottom positions. Such an arrangement would have the advantage of differential port adjustment on the compression and expansion sides while preserving full-width port openings for minimum throttling of air. Any desired means may, of course, be employed to clamp a liner section in fixed position once it has been adjusted.

The term "interdigitated" as used herein refers to any overlapped and interfitted joint providing relative peripheral movement plus smooth vane transition. While flow through the heat exchanger has been referred to as being at constant pressure, it will be understood that minor pressure variations may occur in the heat exchanger without departing from the present invention. Also while the material for thermally isolating the liner may take the form of plastic having lubricating properties, as discussed, it will be apparent that many other stable, poorly conducting solids may be employed, as for example carbon. The term "oval" as used herein is directed toward a chamber having a smoothly continuous outer wall and is not limited to any particular degree of elliptical eccentricity; on the contrary, the eccentricity may approach unity without departing from the present invention.

What I claim is:

1. In a compressor-expander for use in air conditioning, the combination comprising a housing defining a chamber having an outer wall of oval profile having a compression side and an expansion side and enclosed by end plates, a cylindrical rotor extending between the end plates and having a shaft journaled therein, means defining compression side inlet and outlet ports as well as expansion side inlet and outlet ports, a heat exchanger interposed between the compression side outlet port and the expansion side inlet port, the rotor having a plurality of radially movable and outwardly biased vanes extending into engagement with the end plates, a liner in the form of a flexible strip of oval profile covering the outer wall and having port openings in respective communication with the ports in the housing so that a charge of air drawn in between adjacent vanes at the compression side inlet port when the rotor is rotated: (a) is compressed with increase in temperature due to heat of compression, (b) flows at substantially constant pressure through the heat exchanger where heat of compression is absorbed and then (c) expands in the expansion side to produce a sharp drop in temperature for discharge in the cold state through the ex-

pansion side outlet port, the liner being of thin cross section for limited heat conductivity and having a layer of insulation between it and the outer wall for preventing flow of heat through the housing from the compression side to the expansion side.

2. The combination as claimed in claim 1 in which the outer wall of the chamber is formed with pedestals of limited cross section for supporting the liner in oval configuration, the spaces between the pedestals being occupied by insulation.

3. The combination as claimed in claim 2 in which the insulating material between the pedestals is air.

4. The combination as claimed in claim 2 in which each of the pedestals is topped with a thin layer of insulation of predetermined thickness.

5. In a compressor-expander for use in air conditioning, the combination comprising a housing defining a chamber having an outer wall of oval profile divided into a compression side and an expansion side and enclosed by end plates, a cylindrical rotor extending between the end plates and having a shaft journaled therein, means defining compression side inlet and outlet ports as well as expansion side inlet and outlet ports, a heat exchanger interposed between the compression side outlet port and the expansion side inlet port, the rotor having a plurality of outwardly biased vanes extending into engagement with the end plates, a liner in the form of a flexible strip of oval profile covering the outer wall and having port openings in respective communication with the ports in the housing so that a charge of air drawn in between adjacent vanes at the compression side inlet port when the rotor is rotated: (a) is compressed with increase in temperature due to the heat of compression, (b) flows at substantially constant pressure through the heat exchanger where heat of the compression is removed and then (c) expands in the expansion side to produce a sharp drop in temperature for discharge in the cold state through the expansion side outlet port, the liner having externally accessible means for shifting the same peripherally in opposite directions by a slight amount thereby to change the effective phase positions of the ports.

6. The combination as claimed in claim 5 in which the shifting means includes teeth on the outside surface of the liner and a manually operated gear for meshing with the teeth for shifting of the liner in opposite directions.

7. The combination as claimed in claim 5 in which teeth are provided on the outside surface of the liner at substantially diametrical positions, a pair of gears respectively meshing with the teeth, and means for coupling the gears together.

8. The combination as claimed in claim 5 in which the liner is provided with a first set of teeth at a position between the compression side inlet port and the expansion side outlet port and a second set of teeth between the compression side outlet port and the expansion side inlet port, a pair of gears for respectively meshing with the sets of teeth, and means for rotating the gears for imparting equal amounts of peripheral displacement to the liner.

9. The combination as claimed in claim 5 in which first and second sets of teeth are provided on the outer surface of the liner adjacent respective edges of the liner and in which the externally accessible shifting means is in the form of a shaft journaled in the housing and positioned along side of the liner, the shaft having

gears respectively aligned with the sets of teeth for shifting the liner peripherally in opposite directions free of generation of any unbalanced cocking forces.

10. The combination as claimed in claim 5 in which the liner is in the form of an endless loop having engagement means on the outside of the liner at diametrically spaced positions and first and second shifting means penetrating the housing and coupled to the engagement means for imparting equal amounts of shifting movement to the liner.

11. In a compressor-expander for use in air conditioning, the combination comprising a housing defining a chamber having an outer wall of oval profile divided into a compression side and an expansion side and enclosed by end plates, a cylindrical rotor extending between the end plates and having a shaft journaled therein, means defining compression side inlet and outlet ports as well as expansion side inlet and outlet ports, a heat exchanger interposed between the compression side outlet port and the expansion side inlet port, the rotor having a plurality of outwardly biased vanes extending into engagement with the end plates to form compartments which are progressively decreased and then increased in volume as the rotor rotates, a liner in the form of a strip of oval profile covering the outer wall of the chamber and having port openings in respective communication with the ports in the housing so that a charge of air drawn in between adjacent vanes at the compression side inlet port (a) is compressed with increase in temperature due to heat of compression, (b) flows at substantially constant pressure through the heat exchanger where the heat of compression is removed and then (c) expands in the expansion side to produce a sharp drop in temperature for discharge in the cold state through the expansion side outlet port, the liner being of thin cross section for limited heat conductivity and having an isolation layer of predetermined thickness between the liner and the wall, the isolation layer being made of a material having good thermal insulating properties for preventing flow of heat through the housing from the compression side to the expansion side as well as having self-lubricating properties, the liner in addition having externally accessible means for manually shifting the same peripherally in opposite directions by a slight amount thereby to change the effective phase position of the ports.

12. The combination as claimed in claim 11 in which the isolating layer is formed of teflon.

13. The combination as claimed in claim 11 in which the outer wall of the chamber is undercut to provide peripherally spaced pedestals, each of the pedestals being capped by an isolating layer of predetermined thickness formed of a material which combines thermal insulation with self-lubricating properties to facilitate the peripheral shifting of the liner.

14. In a compressor-expander for use in air conditioning, the combination comprising a housing defining a chamber having an outer wall of oval profile divided into a compression side and an expansion side and enclosed by end plates, a cylindrical rotor extending between the end plates and having a shaft journaled therein, means in the housing defining compression side inlet and outlet ports, as well as expansion side inlet and outlet ports, a heat exchanger interposed between the compression side outlet port and expansion side inlet port, the rotor having a plurality of outwardly biased vanes extending into engagement with the end

plates to form compartments which are progressively decreased and then increased in volume as the rotor rotates, a liner in the form of a flexible strip of oval profile covering the outer wall and having port openings in respective communication with the ports in the housing so that a charge of air drawn in between adjacent vanes at the compression side inlet port (a) is compressed with increase in temperature due to heat of compression, (b) flows at substantially constant pressure through the heat exchanger where the heat of compression is removed and then (c) expands in the expansion side to produce a sharp drop in temperature for discharge in the cold state through the expansion side outlet port, means for bodily shifting the liner peripherally in opposite directions by a slight amount thereby to change the effective phase position of the ports, the liner being formed of a thin strip of metal having interdigitated ends which are fitted together to provide a joint having smooth transition with sufficient peripheral clearance and sufficient outward springing to insure seating of the liner on the wall.

15. In a compressor-expander for use in air conditioning, the combination comprising a housing defining a chamber having an outer wall of oval profile divided into a compression side and an expansion side and enclosed by end plates, a cylindrical rotor extending between the end plates and having a shaft journaled therein, means in the housing defining compression side inlet and outlet ports, as well as expansion side inlet and outlet ports, a heat exchanger interposed between the compression side outlet port and expansion side inlet port, the rotor having a plurality of outwardly biased vanes extending into engagement with the end plates to form compartments which are progressively decreased and then increased in volume as the rotor rotates, a liner in the form of a flexible strip of oval profile covering the outer wall and having port openings in respective communication with the ports in the housing so that a charge of air drawn in between adjacent vanes at the compression side inlet port (a) is compressed with increase in temperature due to heat of compression, (b) flows at substantially constant pressure through the heat exchanger where heat of compression is removed and then (c) expands in the expansion side to produce a sharp drop in temperature for discharge in the cold state through the expansion side outlet port, means for bodily shifting the liner peripherally in opposite directions by a slight amount thereby to change the effective phase position of the ports, the liner being formed of a straight strip of flexible material having interdigitated ends which are fitted together and which have end-to-end clearance with means for relatively moving the ends toward one another to slightly reduce the length, hence the diametrical dimension, so that the liner is lifted free of the wall of the chamber to facilitate the shifting movement.

16. The combination as claimed in claim 15 in which a layer of lubricating material is interposed between the liner and the wall for the purpose of lubricating the shifting movement at those portions of the liner which remain in contact with the wall.

17. The combination as claimed in claim 15 in which the ends of the liner are formed into interdigitated fingers which are fitted together with end-to-end clearance, the fingers having abutments adjacent the tips thereof, and means for engaging associated abutments to produce a reduction in the end-to-end clearance

with consequent reduction in the diametrical dimension so that the liner is lifted free of the wall followed by shifting movement thereof to a new position.

18. The combination as claimed in claim 15 in which the ends of the liner are formed into interdigitated fingers having first and second set of abutments at the respective tips thereof and providing limited end-to-end clearance, and an adjusting member penetrating the housing for alternatively engaging one of the sets of abutments to apply pressure thereto in the peripheral direction for (a) taking up the end-to-end clearance thereby to reduce the diametrical dimension so that the liner is lifted free of the wall accompanied by interdigitated bottoming of the fingers, and (b) upon continued movement effecting bodily shifting of the liner to a new position for adjustment of the phase position of the ports, following which the adjusting means is backed off to restore seated contact between the liner and the wall.

19. The combination as claimed in claim 15 in which the first and second ends of the liner have fingers which are interdigitated and lie closely side by side with limited clearance at the ends of the fingers and in which means are provided for alternatively applying traction to the respective ends of the liner with the result that the end clearance is taken up for slightly reducing the diametrical dimension of a liner thereby to lift it clear of the wall followed by bodily shifting of the liner to a new phase position.

20. The combination as claimed in claim 15 in which abutments are provided on the respective ends of the liner for applying traction thereto and in which a unitary adjusting member is provided having means for imparting shifting movement in opposite directions for alternatively engaging the abutments for unseating the liner from the wall of the housing and for subsequently imparting bodily shifting movement to the liner for adjusting the same to a new phase position.

21. In a compressor-expander for use in air conditioning, the combination comprising a housing defining a chamber having an outer wall of oval profile divided into a compression side and an expansion side, and enclosed by end plates, a cylindrical rotor extending between the end plates and having a shaft journaled therein, means in the housing defining a compression side inlet port, compression side outlet port, expansion side inlet port, and expansion side outlet port, a heat exchanger interposed between the compression side outlet port and the expansion side inlet port, the rotor having a plurality of vanes extending into engagement with the end plates and outwardly biased so that adjacent vanes define compartments which are progressively decreased and then increased in volume as the rotor rotates, a liner in the form of a plurality of thin flexible strips of oval profile merging smoothly edge to edge and extending between the end plates, the strips each having port openings communicating with a portion of the ports in the housing and at least a portion of the strips being peripherally adjustable to vary the relative phase positions of the ports.

22. In a compressor-expander for use in air conditioning, the combination comprising a housing defining a chamber having an outer wall of oval profile divided into a compression side and an expansion side and enclosed by end plates, a cylindrical rotor extending between the end plates and having a shaft journaled therein, means in the housing defining a compression

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side inlet port, compression side outlet port, expansion side inlet port, and expansion side outlet port, a heat exchanger interposed between the compression side outlet port and the expansion side inlet port, the rotor having a plurality of vanes extending into engagement with the end plates and outwardly biased to form compartments which are progressively decreased and then increased in volume as the rotor rotates, a liner in the form of a pair of thin flexible strips of oval profile merg-

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ing smoothly edge to edge for covering the outer wall, the strips each having port openings communicating with a portion of the ports in the housing and at least one of the strips being peripherally adjustable to vary the relative phase positions of the ports.

23. The combination as claimed in claim 22 in which both of the strips are peripherally shiftable and provided with position adjusting means.

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